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THE RELATION OF MINIMUM AIR TEMPERATURES AND CORRESPONDING MINIMUM TEMPERATURES IN THE BARK OF PONDEROSA PINE TREES AT HACKAMORE, CALIF.

by
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INTRODUCTION

It is known that field temperatures in forested areas occasionally are low enough to cause a considerable mortality in barkbeetle broods overwintering in the bark of infested ponderosa pine trees. In the laboratory, Miller (6) and others (7,8) have determined the mortality that can be expected following exposure of broods to known temperatures for known periods of time. That work has shown that, although exposure for periods of time longer than oue hour increased the brood mortality, the intensity of the cold rather than the length of time of exposure appears to be the more important factor. The data that have been secured in the laboratory studies provide a basis for field estimates of population reduction from low temperatures, providing certain things are known.

Air temperature records are customarily the ones secured at established weather recording stations. However, bark temperatures and not air temperatures are the ones to which the overwintering broods actually are exposed. There may be a considerable spread between comparable air and bark temperatures. If air temperature records are to be used to determine cold intensity affecting broods, they must represent the conditions of the forested area and their pertinence must be known. The relation between air and bark temperatures must be known as well as the degree of accuracy it is possible to secure in estimating bark temperatures from air temperature records. If air temperatures are not pertinent or if the relation between the air temperatures and those actually affecting the larvae in the bark is not known, expensive field work or special apparatus to record bark temperatures will have to be secured to supply the missing link in estimating brood mortality due to low temperatures.

OBJECTIVES

The objectives of this study are to find out (1) if the relation between bark and air minimum temperatures can be determined accurately enough to warrant the use of air temperatures in estimating bark temperatures. (2) What are the limits of accuracy of such estimates under certain conditions. (3) What are the effects of certain factors on (a) the relation of air and bark minimum temperatures and (b) the accuracy of that relation. The practical application of the results of such a study, if successful, would be the ability to use pertinent air temperature records in estimating actual temperature and brood conditions under the bark of infested trees. Under the variable air temperature conditions existing in the forest, a knowledge of

the effective , or bark temperatures, is missing in our attempts to determine the relation of low air temperatures and brood mortality.

PREVIOUS WORK

Beal (1) took hourly readings of air and bark temperatures during a cold period. He found that bark temperatures were from 8 to 29 degrees higher than the air. Bark thickness was believed to be responsible for much of this variation.

Keen and Beal (4) found that air temperatures were, in general, about ten degrees lower than bark temperatures and that there was a very direct relationship between the two. They constructed a curve showing the relation of mortality and air temperatures (see also Furniss - 3). Keen and Furniss (5) made the following statement: "- The data, although not conclusive, indicate that, given the same minimum temperatures, the prolonged cold was most effective, the unseasonable cold less effective, and the intense cold least effective in reducing western pine beetle populations." Although these statements refer to brood mortality resulting from low air temperatures, they could, for the purpose of applying them in this study, substitute the words "bark temperatures" for "western pine beetle populations".

BASIC DATA

Keen's office (2) is investigating the relations of temperature at established weather stations in Oregon and temperatures in nearby forested areas. They also are determining the effects of certain factors such as slope and topography in modifying temperatures or in accounting for variations. For three years the Berkeley laboratory has been investigating another phase of the problem at Hackamore, in the Modoc National Forest. A weather station with a recording air thermograph was established in the forest and bark temperature records have been taken from infested and uninfested ponderosa pine within a radius of about 300 yards from the weather shelter providing the air record. Within this radius, topographic and forest conditions are as uniform as can be secured in the field. This arrangement should provide for a test with a very pertinent temperature record, under the most favorable of field conditions.

Analyses were made of minimum air temperature records which were paired with minimum readings for the same temperature depressions from the following trees. BE 49 (5/7/34 to 8/25/34), BE 54 (6/19/34 to 7/18/34), BE 72 (10/17/34 to 6/29/35), BE 75 (3/12/35 to 7/10/35), BE 87 (6/23/35 to 8/29/35), BE 88 (7/10/35 to 10/9/35), BE 102 and 103, both north and south sides from 7/20/36 to 2/22/37.

The air temperature record was taken by a Friez Hygrothermograph. Bark temperatures were taken by Foxboro Anti-Ambi (fully compensated) distance recording thermographs. Bark insulation on the several trees ranged from a thickness of ½ to 1½ inches over the sensitive portion of the bulb.

METHOD OF ANALYSIS

The data were selected as follows:- Paired readings were taken for every fifth day from the tree and air temperature records. These were listed in table form. Additional paired readings were added to this list to strengthen the data for air temperatures below 20° F. Other paired readings were added where needed to strengthen the data for special studies of factors influencing the minimum bark temperatures. These readings also were used to check the original data which formed the basis for the average curve.

The general method used in computing the data was as follows:- The average minimum bark temperature for each minimum air temperature was determined and ploted over minimmm air temperatures. A balanced free hand curve was drawn through the plotted data. Where necessary, a weighted five class moving average was used to reduce the spread of the plotted points and to establish the trend of the curve.

Statistical values were determined by the following formulae:-

1. Mean air and mean bark temperature $M = \frac{\Sigma T}{N}$

2. Standard deviation of the mean $\sigma M = \sqrt{\frac{\Sigma D^2}{N-1}}$ where D is the difference between the actual minimum temperature and the mean minimum temperature.

3. Standard error of estimate $\sigma E = \sqrt{\frac{\Sigma E^2}{N-1}}$ where E is the difference between the actual and the estimated minimum bark temperature.

4. Coefficient of correlation $r = \frac{\Sigma XY - (\Sigma Y \times MX)}{\sqrt{\Sigma Y^2 - (\Sigma Y \times MY) - \Sigma X^2 (\Sigma X \times MX)}}$ where Y is the independent variable (minimum air temperature) and X is the dependent variable (minimum bark temperature).

5. Index of alienation $AI = \frac{\sigma E}{\sigma M}$

6. Index of correlation $CI = \sqrt{1 - AI^2}$

7. Standard error of the standard error. $\frac{\sigma E}{\sqrt{2N}}$

RESULTS

1. Relation of minimum air and minimum bark temperatures.

The curve (figure 1) represents the relation drawn from analysis of 389 paired readings from one air and eleven bark temperature records. It has a decreasing degree of curvature as the minimum air temperatures increase and tends to be a straight line at the higher temperatures. The minimum bark temperatures read from this curve are tabled in column 2 of table 1.

The mean munimum air temperature is 24.6° F. and the mean minimum bark temperature for those readings is 38.0° F. The following were the results of statistical tests of significance of correlation.

Standard deviation of the mean bark temperature	± 16.36° F.
Standard error of estimate	± 4.70° F.
Standard error of estimate of the means	± 3.16° F.
Index of alienation	.287
Index of correlation	.958
Coefficient of correlation	.953
Standard error of the standard error	± 0.17° F.

The correlation of minimum bark with minimum air temperatures is very highly significant and the chances are two to one that, for a given minimum air temperature, the actual bark temperature will be within ± 4.70° F. of the bark temperature calculated from the curve. This curve is a general one drawn from bark temperature data taken from north, south and east sides of trees, under covers of bark having some variation in thickness and over long enough periods of time so that markedly different climatic conditions have influenced the record.

If this curve is to be of general use and its accuracy in estimating bark temperatures is limited to ± 4.70° F. it would be well to know if any smaller estimate of error could be secured by segregating and determining effects of such features as can be studied in the data at hand.

2. Comparison of the standard errors of estimate of different parts of the curve.

It is possible that relations between air and bark minimum temperatures are different at the lower, the middle or the upper range of the curve in figure 1. Under certain conditions it may be that parts of the curve are more or less representative of the data. In order to test this, the standard error of estimate was determined for each of three segments of the curve. They were found to be as follows:-

Standard error of estimate of -30° F. to 0° F.	± 4.6° F.
Standard error of estimate of 0° F. to + 30° F.	± 4.7° F.
Standard error of estimate of + 30° F. to + 60° F.	± 4.9° F.

No significant differences are indicated by the values of the standard errors of estimate for different segments of the curve.

3. Effects of daily temperature trends.

This analysis involved the use of 458 paired readings.

The normal daily temperature trend is V-shaped with the minimum temperature occurring between two and eight A.M. The temperature decreases steadily to the minimum and rises sharply afterwards. This type is normal, but other types occasionally are found in the record. It was thought advisable to examine the data and determine if the type of daily temperature record affected the relation between the minimum air temperature and the minimum bark temperature. This was done for the normal type of daily temperature trend and for the following types as well.

Early minimum:- This is a type in which the minimum temperature of the daily depression is reached before two A.M. and the complete daily record is otherwise the normal V-shaped type. Usually this type has a short period of low temperature preceded and followed by sudden rises.

Sustained minimum:- This type has temperatures remaining at or near the minimum for three or more hours and the thermograph shows a U-shaped type of daily record.

Late minimum:- In this type, the minimum occurs after eight A.M. A lack of sufficient data prevented analysis of this daily trend. Usually there is a gradual decrease in temperatures during the night with long exposure to lowering temperatures followed by a sudden increase after the minimum has occurred.

Curves for the three types of daily temperature trends are plotted in figure 2. It is seen that the curves for each type are similar to the curve plotted for all data in figure 1. The curve for normal daily trends is a little higher than the average curve. That for the early minimum in which there is but a short period of low temperature, shows values slightly lower than average. Exposure for three or more hours to low temperatures which is illustrated by the curve for the sustained minimum, results in lower bark temperatures. These data agree with the general conclusions reached by previous workers but, in addition, provide a possible means for measuring the accuracy of estimated bark temperatures under the different trend conditions. The following stastical values and tests of significance or correlation were worked out for the three types of daily temperature trends. Corrections of the average data for variations due to the daily temperature trends are tabled in column 8 to 10 of table 1.

	Normal	Early min.	Sus. min.	Combined data
No. of observations	228	86	144	458
Mean min. air temp.	26.2°F	22.1° F	25.9° F	24.0° F
Mean min. bark temp.	40.6°F	31.4° F	33.0° F	36.5° F
Standard dev. bark temp.	±16.39°F	± 14.93°F	± 9.43°F	
Stan. error of estimate	± 4.09°F	± 4.10°F	± 3.82°F	± 4.52°F
Alienation index	.249	.275	.405	
Correlation index	.968	.962	.914	
Stan. error of stan. error	± 0.19° F	± 0.31° F	± 0.23°F	± 0.15°F

The standard error of estimate for the combined data is based on the curve of the average or general data from the eleven bark and one air records. It checks the fit of the second set of data to the original curve and shows it fits better than the original data as indicated by the smaller standard error of estimate. By breaking the temperature trends into types, it seems possible to reduce the standard error of estimate by from 0.60 to 0.88° F. Apparently different daily temperature trends have considerable influence on the bark temperatures.

4. Variations in individual trees.

Up to this point in the analysis we have been concerned with bark temperature data originating under a variety of circumstances. The record of an individual tree for which temperatures were known from both the north and south sides has been analyzed to find if the error of estimate is reduced significantly when variables introduced by the use of records from other trees are eliminated. Those variables are differences in exposure, bark thickness, shade and sunlight and the air movement factors, all of which vary exceedingly when more than one tree is considered.

A curve for normal daily temperature trends and from both the north and south sides of tree 102 is shown in figure 3. The tests of significance and correlation for these records are as follows:-

	102 n.	102 s.	102 both sides
Number of observations	31	31	62
Mean minimum bark temperature	40.4° F	40.5° F	40.5° F
Standard deviation	±18.18°F	±15.91°F	±16.94°F
Standard error of estimate	± 2.58°F	± 2.76°F	± 2.75°F
Alienation index	.142	.173	.162
Correlation index	.990	.986	.987
Standard error of standard error	± 0.30° F	± 0.32°F	± 0.25°F

Under the normal type of daily temperature trend, consideration of the bark temperature records of but one tree reduces the standard error of estimate by from 1.04 to 1.51° F. below that for all trees. The standard error under all conditions was determined for the record from the north side of the tree as ± 3.38° F. This is 1.32° F. less for the single

tree than for all trees under all conditions. These values show that differences in individual trees may account for more than 25 per cent of the standard error of all trees under all daily temperature trends.

The records from north and south sides of tree 102 furnish an opportunity to study the effect of exposure. The mean minimum bark temperature of the north side was but one tenth of a degree different from that for the south side (see above table). Only paired readings taken on identical nights were used in arriving at those means which show very little difference. Curves for the two exposures are similar and very close although that for the south side has the smaller standard error of estimate. It cannot be concluded, from our data, that the exposure has any great or consistent effect on the minimum bark temperatures.

5. Variations in the daily differences between the minimum and maximum air temperatures.

It was thought that the differences between minimum air and minimum bark temperatures on given days might be related to or influenced by the range of air temperatures during those days. When this relation was considered for all trees and conditions, the plotted points were so scattered that no curve was constructed. A general trend showed that greater differences between the minimum bark and air temperatures were associated with larger diurnal temperature ranges. When the same data were divided into seven ten degree classes based on the minimum air temperatures for the day, the resulting graphs (figure 4) showed that a slight increase in difference between minimum air and bark temperatures accompanied the larger daily air temperature fluctuations.

The next point to be analyzed is the relation of the amount of daily air temperature fluctuation and its effect on the relations of minimum air and minimum bark temperatures. This was done for ten degree daily temperature range classes for all trees under all conditions and for tree 102 north, under all conditions. Curves for the five ten-degree daily range calsses for all trees are plotted in figure 5. Curves for tree 102 north are given in figure 6. Those curves have trends similar to that of the average curve (figure 1). However, a daily range of 0 to 9° F. lowers the average readings by from 5 to 7° F. A 10 to 19° F. range lowers the average readings by from 1 to 7° F. A range of from 20 to 29° F. lowers the average readings by from ½ to 2½° F. The ranges of from 30 to 39° F. and 40 to 50° F, raise the average readings by from 0 to 3° F. The curve of the range from 30 to 39° F. approaches the average curve as temperatures increase while that of from 40 to 50° F. approaches the average as temperatures decrease. This same opposite tendency occurred in the single tree record for the same ranges. Its cause is not known. Corrections of the average curve readings for differences in the daily temperature ranges are tabled in Table 1, columns 3 to 7. These corrections cannot be used in addition to those for daily temperature trends but should be used alone. Tests of the significance and correlation of results are as follows:-

Temperature ranges	No. of observations	Mean min. air temp.	Mean min. bark temp.	Stan. dev. of mean	Standard error	Alien. index	Corr. index	St. error of stand. error
All trees								
0-9 °F	44	23.4 °F	31.6 °F	± 7.34 °F	± 3.13°F	.426	.905	± 0.33 °F
10-19 "	93	21.5	31.5	± 11.41	± 3.39	.297	.955	± 0.25
20-29 "	107	22.7	35.4	± 16.25	± 3.76	.231	.973	± 0.26
30-39 "	151	22.0	36.5	± 18.80	± 3.81	.203	.979	± 0.21
40-50 "	173	37.4	51.7	± 8.96	± 3.73	.416	.909	± 0.21
Tree 102 N								
0-9 °F	14	21.9	29.5	± 7.21	± 1.79	.248	.969	± 0.39
10-19 "	23	19.3	29.0	± 10.47	± 2.07	.198	.985	± 0.31
20-29 "	27	19.7	31.8	± 20.49	± 2.67	.130	.991	± 0.36
30-39 "	52	23.4	38.0	± 13.96	± 2.43	.174	.984	± 0.26
40-50 "	68	35.5	49.8	± 9.16	± 1.88	.207	.978	± 0.16

By breaking the air temperature data into five classes based on the amount of daily air temperature range, the standard error of estimate is reduced by from 1.0 to 1.6 °F. A reduction of the standard error of estimate (1.0 to 1.8 °F.) also is possible by considering only the record from one tree.

TESTS OF THE ACCURACY OF BARK TEMPERATURE ESTIMATES.

In order to test how the values determined from the curves as given in table I apply under other conditions, analyses were made of 63 paired readings from one air and three bark temperature records taken at Hackamore between December 1, 1937 and February 7, 1938.

Estimates were made from the average curve and corrections were also made for the daily temperature range. Standard errors of estimate were as follows:-

Original data - Stand. error of est. for average conditions	$\pm$ 4.70° F
1937-38 data - Stand. error of est. for average conditions	$\pm$ 5.28°F
Original data - Stand. error of est. corrected for daily range	$\pm$ 3.61° F
1937-38 data - Stand. error of est. corrected for daily range	$\pm$ 4.09° F

The new data raised the standard error of estimate in both comparisons. This indicates that the curves are poorer fits for the 1937-38 than for the original data.

It is possible to determine the per cent of observations that should have less than given standard errors of estimate on a theoretical basis. It also is possible to determine how many of the actual bark temperatures had deviations from the calculated temperatures of less than certain amounts. The following results were secured in these comparisons.

Limits of standard error	Percent of observations		
	Theoretical expectation	Est.on ave. curve	Ave.curve est.corrected for daily air temp.range
1 xσE ($\pm$ 4.70° F.)	68.3%	57.1%	65.1%
2 xσE ($\pm$ 9.40° F.)	95.5%	95.2%	93.6%
3 xσE ($\pm$ 14.10° F.)	99.7%	100.0%	98.4%

The corrected estimates were distributed in relation to the actual bark temperatures in a manner very similar to that which would be expected on a theoretical basis. The estimates uncorrected for daily temperature ranges were almost exactly the same for two and three times the standard error but were far off up to the amount of the standard error of estimate.

It is believed that this inaccuracy of estimate was due to the occurrence of a large proportion of days of low temperature ranges. That condition would make for considerable difference in the estimates (see figure 5.).

It is apparent that, if corrections are made for daily temperature ranges, the distribution of calculated bark temperatures will be similar to that of those occurring in the field. However, when interpreted in terms of brood mortality the estimates can only be general and cannot be applied to individual trees or to a small number of trees without expecting an error of considerable size. The reason for that statement lies in an analysis that has been made of the results of laboratory experiments on the relation of brood mortality to temperatures of exposure.

ANALYSIS OF EXPERIMENTAL RESULTS ON THE RELATION OF BROOD MORTALITY TO TEMPERATURES OF EXPOSURE

Miller (6) and others (7,8) have done a considerable amount of laboratory work in which broods of the western pine beetle were exposed to temperatures in or near to the lethal range. The basic data available for analysis is supplied by that work. It consists of 64 separate tests on full grown western pine beetle larval brood samples including 4953 individual larvae. So far as could be determined all samples had been conditioned, either naturally or artificially. They could be considered to be in approximately the same condition as those overwintering in the field in infested trees.

The temperature of exposure is comparable to bark temperatures and the tests were carried on over a period of several years. The temperatures of the tests ranged from + 10° F. to - 18° F. Mortality started at + 10° F., but was slight until the + 2½° F. point was reached. For all practical purposes, mortality at temperatures above 2½° F. have been and probably can correctly be considered almost entirely due to handling and not to the cold. Between + 2½° F. and - 8° F. the rise in mortality is rapid with fully 90 per cent of the range occurring between those two points. The lower temperature usually caused a hundred per cent mortality.

Individual tests at a given temperature often showed considerable difference in results. The workers have concluded that much of this difference is due to differences in the broods, particularly differences resulting from variations in conditioning temperatures. When each test was considered singly, the standard error of estimate for the curve drawn from the 64 tests was ± 10.7 per cent. This means that the chances are two to one that the mortality at a given temperature of exposure for all overwintering broods can be estimated within a range of 29 per cent. If all tests at a given temperature are averaged, the standard error of estimate of the averages is reduced to ± 4.87° F. or a range of about nine per cent.

It is apparent that analysis of existing experimental results does not support the hope that mortality for given temperatures of exposure can be estimated with a high degree of accuracy. The rapid rise of mortality accompanying decreases in temperatures below + 2½° F. makes it more difficult to secure accuracy of estimates within that lethal range.

CONCLUSIONS

1. A close association exists between minimum air temperatures and minimum bark temperatures. This is shown by the high indices of correlation that have been secured from the analysis.

2. Minimum bark temperatures may be estimated from minimum air temperatures for all trees and all climatic conditions affecting the experimental setup at Hackamore with an accuracy equal to a standard error of estimate of $\pm$ 4.70° F. Thus the chances are two to one that the actual bark temperatures will be within that range of values estimated from the curve in figure 1.

3. By elimination of one or more of the chief factors that cause the standard error of estimate, it is possible to reduce the error by from 0.6 to 2.9° F. Of these factors, daily temperature trends, variations in the conditions surrounding and inherent in individual trees, and the amount of daily temperature range appear to be the most important. Each of the last two factors contributes approximately one fourth of the standard error of estimate.

4. Corrections of the average curve can best be made for the amount of daily temperature range (see Table I). Those corrections can be determined from the thermograph record or from readings of a maximum-minimum thermometer. The corrections increase the accuracy of estimate considerably.

5. Corrections for variations in individual trees cannot be made without a more detailed knowledge of the factors causing the variation. In addition, when considering the general conditions of temperature surrounding broods in a given area, the average conditions and not particularly those in individual trees are the ones desired. It is doubtful if the accuracy possible in determining bark temperatures from air temperatures is sufficient to allow the satisfactory determination of temperature conditions in individual trees.

6. If a normal distribution of the standard errors of estimate is assumed, two thirds of the standard errors of estimates, or other samples of data under all conditions and taken in the same locality will have values between $\pm$ 4.53 and $\pm$ 4.87° F. Ninety-five percent of the values will be between $\pm$ 4.36 and $\pm$ 5.04° F.

7. The relation of minimum air to minimum bark temperatures changes along the temperature scale and at Hackamore, the difference between the two varied from 1 to 24° F. Thus there appears to be no fixed spread between all air and bark minimum temperatures.

8. The relation between air and bark temperatures statistically is very highly significant. A similar clear relation seems to exist between mortality and bark temperatures or the temperatures of exposure.

However, the possible margin of error in calculating the dependent variables (bark temperature or mortality) from the independent variables (air temperature or bark temperature of exposure) seem too great to produce accurate estimates. It seems possible, for given stations supplying pertinent air temperature records, to determine air-bark temperature relations by experimentation to provide a basis for general estimates of brood mortality when lethal temperatures occur.

9. Such estimates will be of most value when the temperatures are low enough to produce a considerable mortality and of the least value when they will produce but slight mortality.

10. It is not substantiated by the analyses described in this report that it is possible to make very accurate estimates of bark temperatures or of temperatures of exposure from an air temperature record, even under conditions where the air temperature record is highly pertinent.

11. It also is not established, even though the temperature of exposure is known, that brood mortality can be estimated from air temperature records without considerable error.

REFERENCES

1. Beal, J. A.
Relation of air and bark temperatures of infested ponderosa pine during sub-zero weather. Feb. 24, 1933.

2. Buckhorn, W. J. and R. L. Furniss
Report for the period January 8 to 15, 1937 Re: Low temperatures, Ochoco National Forest. January 16, 1937.

3. Furniss, R. L.
Additional observations of the effects of low temperatures upon overwintering populations of Dendroctonus brevicomis Lec. Oregon, 1935. Feb. 19, 1936.

4. Keen, F. P. and J. A. Beal
Low temperatures as a limiting factor in western pine beetle epidemics. Progress Report No. 1. April 30, 1933.

5. Keen, F. P. and R. L. Furniss
Effects of sub-zero temperatures on populations of the western pine beetle. Jour. Econ. Ent. 30 (3): 482-504, 1937.

6. Miller, J. M.
High and low lethal temperatures for the western pine beetle. Jour. Agri. Res. 43 (4): 303-321, 1931.

7. Miller, J. M. and G. R. Struble
Critical low temperatures for the western pine and mountain pine beetles. Progress report of laboratory studies, 1933-34. Feb. 28, 1935.

8. Yuill, J. S.
Memorandum on laboratory records, January to April 1936. Critical low temperatures for the western pine and mountain pine beetles. April 15, 1936.

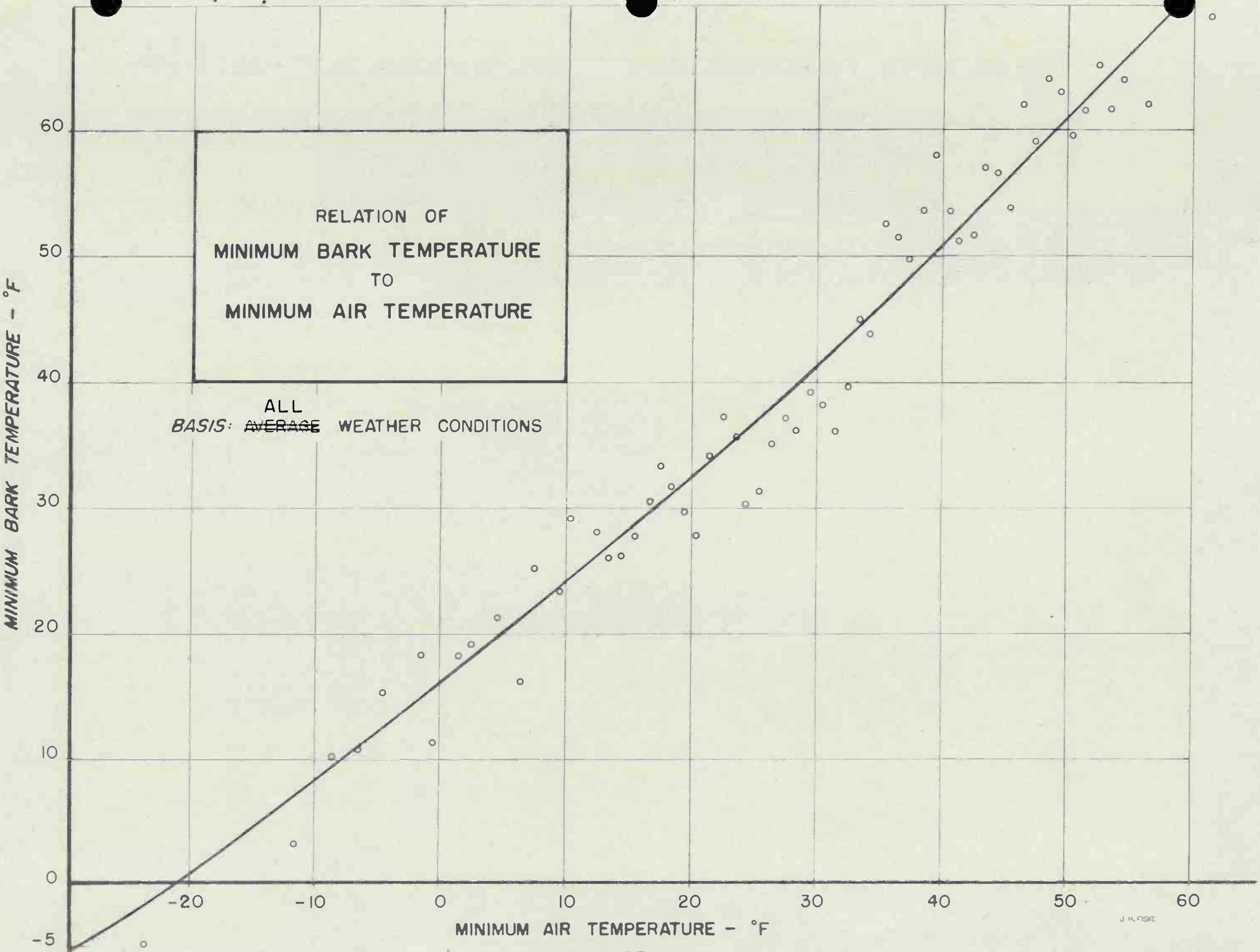
Table I

MINIMUM BARK TEMPERATURES ESTIMATED FROM MINIMUM AIR TEMPERATURES

Min. air temp.	Min. bark temp. Av. cond.	Corrections							
		Daily temperature range					Daily temp. trend		
		0-9	10-19	20-29	30-39	40-50	Normal	E. min.	S.min.
σE	± 4.70	3.13	3.39	3.76	3.81	3.73	4.09	4.10	3.30
-30	-6			0	+3		+3	- .5	
-29	-5			- .5	3		2.5	- .5	
-28	-4.5			- .5	3		2.5	- .5	
-27	-4			- .5	3		2.5	- .5	
-26	-3			- .5	2.5		2	- .5	
-25	-2.5			- .5	2.5		2	- .5	
-24	-2			- .5	2.5		2	- .5	
-23	-1			-.5	2.5		2	- .5	
-22	-0.5			- .5	2.5		2	- .5	
-21	0			- .5	2.5		2	- .5	
-20	+1		-2	- .5	2.5		2	-.5	
-19	1.5		-1.5	- .5	2.5		2	- .5	
-18	2.5		-1.5	- .5	2.5		1.5	- .5	
-17	3		-1.5	- .5	2.5		1.5	- .5	
-16	4		-1.5	- .5	2.5		1.5	- .5	
-15	4.5		-1.5	- .5	2.5		1.5	- .5	
-14	5.5		-1.5	- .5	2.5		1.5	- .5	
-13	6		-1.5	- .5	2.5		1.5	- .5	
-12	7		-1.5	- .5	2		1.5	- .5	
-11	7.5		-1.5	- .5	2		1.5	-1	
-10	8		-1.5	- .5	2		1.5	-1	
- 9	9		-1.5	- .5	2		1.5	-1	
- 8	10		-1.5	- .5	2		1.5	-1	
- 7	10.5		-1.5	- .5	2		1.5	-1	
- 6	11.5		-2	- .5	2	1.5	1.5	-1	
- 5	12		-2	- .5	2		1.5	-1	
- 4	13		-2	- .5	2		1.5	-1	
- 3	14		-2	- .5	2		1.5	-1	
- 2	14.5		-2	- .5	2		1.5	-1	
- 1	15.5		-2	- .5	2		2	-1	
0	16	-5.5	-2	- .5	2		2	-1	-4.5
+ 1	17	-5.5	-2	- .5	2		2	-1	-4.5
2	18	-5.5	-2	- .5	2		2	-1	-5
3	18.5	-5.5	-2	- .5	2		2	-1	-5
4	19.5	-5.5	-2	- .5	2		2	-1	-5
5	20	-5.5	-2	- .5	2		2	-1	-5
6	21	-6	-2.5	-1	2	0	2	-1	-5
7	22	-6	-2.5	-1	2	0	2	-1	-5.5
8	23	-6	-2.5	-1	2	0	2	-1	-5.5
9	23.5	-6	-2.5	-1	2	0	2	-1	-5.5
10	24.5	-6	-2.5	-1	2	0	2	-1	-5.5
11	25	-6	-2.5	-1	2	0	2	-1	-5.5

Table I (Cont.)

Min. air Temp.	Min. bark temp. Av. cond.	Corrections							
		Daily temperature range					Daily temp. trend		
		0-9	10-19	20-29	30-39	40-50	Normal	E. min	S. min.
σE	± 4.70	3.13	3.39	3.76	3.81	3.73	4.09	4.10	3.30
12	26	-6	-2.5	-1	2	0	2	-1	-5,5
13	27	-6.5	-3	-1	2	0	2	-1	-5.5
14	28	-6.5	-3	-1	2	0	2	-1	-5.5
15	28.5	-6.5	-3	-1	2	.5	2	-1	-5.5
16	29.5	-6.5	-3	-1	2	.5	2	-1	-5.5
17	30	-6.5	-3	-1	2	1	2	-1	-5
18	31	-6.5	-3	-1	2	1	2	- .5	-5
19	32	-6.5	-3	-1	2	1	2	- .5	-5
20	32.5	-6.5	-3	-1	2	1.5	2.5	- .5	-5
21	33.5	-6.5	-3	-1	2	1.5	2.5	- .5	-5
22	34.5	-6.5	-3.5	-1	2	1.5	2.5	- .5	-4.5
23	35	-6.5	-3.5	-1	2	2.5	2.5	- .5	-4.5
24	36	-6.5	-3.5	-1	2	2	2.5	- .5	-4.5
25	37	-6.5	-3.5	-1	1.5	2	2.5	- .5	-4.5
26	38	-6.5	-3.5	-1	1.5	2	2.5	- .5	-4.5
27	38.5	-6.5	-3.5	-1	1.5	2	2.5	- .5	-4.5
28	39.5	-6.5	-3.5	-1	1.5	2.5	2.5	- .5	-4.5
29	40.5	-7	-3.5	-1	1.5	2.5	2.5	- .5	-4.5
30	41.5	-7	-3.5	-1	1.5	2.5	2.5	- .5	-4.5
31	42.5	-7	-3.5	-1	1.5	2.5	2.5	- .5	-4.5
32	43	-7	-3.5	-1	1.5	2.5	2.5	- .5	-4.5
33	44	-7	-4	-1	1.5	3	2.5	- .5	-4.5
34	45	-7	-4	-1	1.5	3	2.5	- .5	-4.5
35	46	-7	-4	-1	1.5	3	2.5	- .5	-4.5
36	47	-7	-4.5	-1	1.5	3	2.5	- .5	-5
37	48	-7	-4.5	-1	1.5	3	2.5	- .5	-5
38	49	-7	-5	-1.5	1	3	3	- .5	-5
39	50	-7	-5	-1.5	1	3	3	- .5	-5
40	51	-7	-5	-1.5	1	3	3	- .5	-5
41	52		-5.5	-1.5	1	3	3	- .5	-5
42	53		-5.5	-1.5	1	3	3	- .5	-5
43	54		-5.5	-2	.5	3	3	- .5	-5
44	55		-6	-2	.5	3	3	- .5	-5
45	56		-6	-2	.5	3	3	- .5	-5
46	57		-6	-2	.5	3	3	- .5	-5
47	58		-6.5	-2	.5	3	3	- .5	-5
48	59		-6.5	-2	0	3	3	- .5	-5
49	60		-6.5	-2	0	3	3	- .5	-5
50	61		-7	-2	0	3	3	- .5	-5
51	62			-2.5	0		3	- .5	-5
52	63			-2.5	0		3	- .5	-5
53	64			-2.5	0		3	- .5	-5
54	65			-2.5	0		3	-.5	-5
55	66.5			-3	-.5		3	- .5	-5
56	67.5			-3	-.5		3	- .5	
57	68.5			-3	-1		3	- .5	
58	69.5			-3.5	-1		2.5	- .5	
59	70.5			-3.5	-1		2.5	- .5	
60	71.5			-3.5	-1		2.5	- .5	
61	72.5			-3.5	-1		2.5	- .5	



RELATION OF
MINIMUM BARK TEMPERATURE
TO
MINIMUM AIR TEMPERATURE
BASIS: ~~AVERAGE~~ ALL WEATHER CONDITIONS
MINIMUM BARK TEMPERATURE - °F
MINIMUM AIR TEMPERATURE - °F
60
50
40
30
20
10
0
-5
-20
-10
0
10
20
30
40
50
60
J. H. FISKE

FIGURE 1

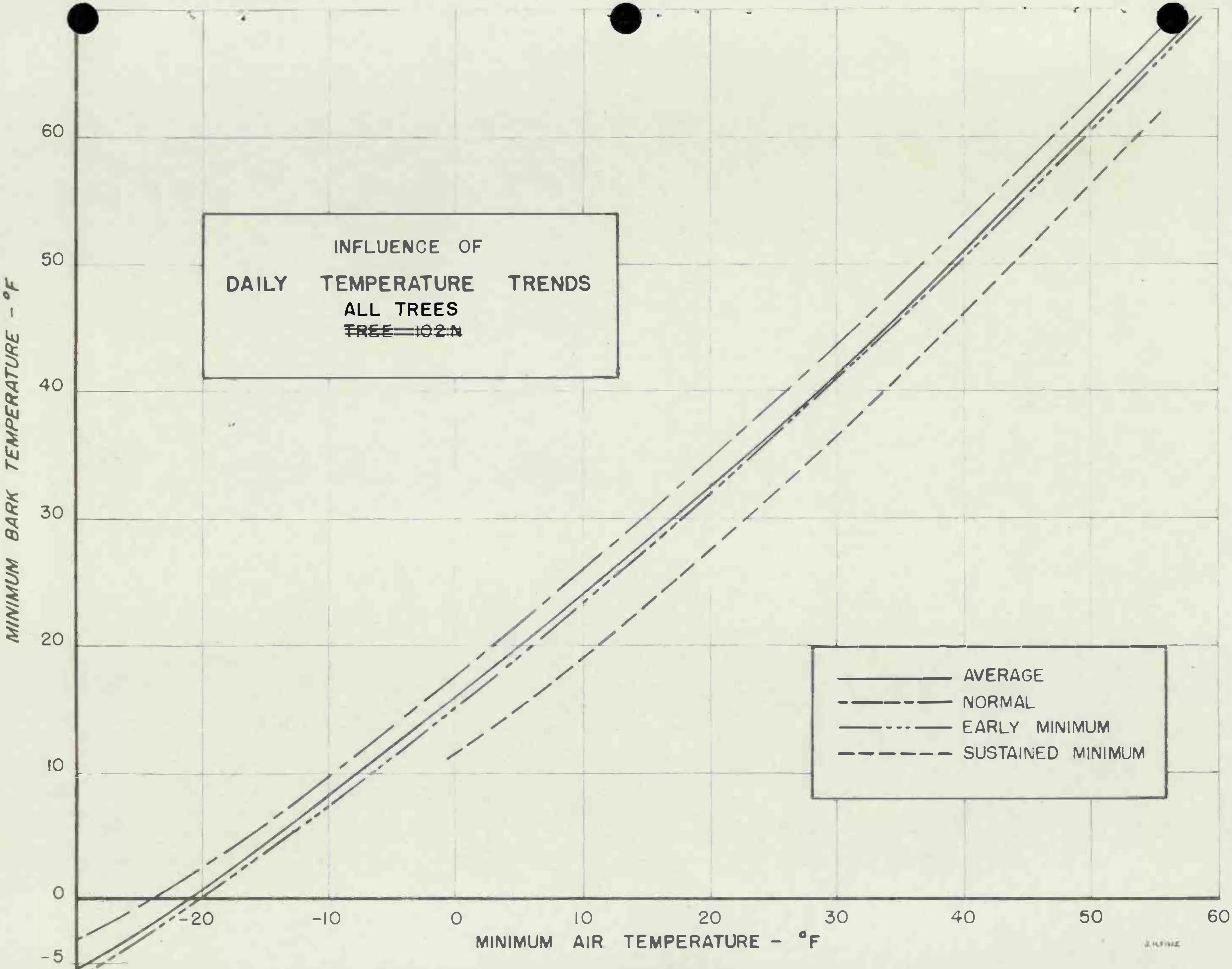

INFLUENCE OF
DAILY TEMPERATURE TRENDS
ALL TREES
~~TREE 102 N~~
AVERAGE
NORMAL
EARLY MINIMUM
SUSTAINED MINIMUM
MINIMUM BARK TEMPERATURE - °F
MINIMUM AIR TEMPERATURE - °F
60
50
40
30
20
10
0
-5
-20
-10
0
10
20
30
40
50
60

FIGURE 2

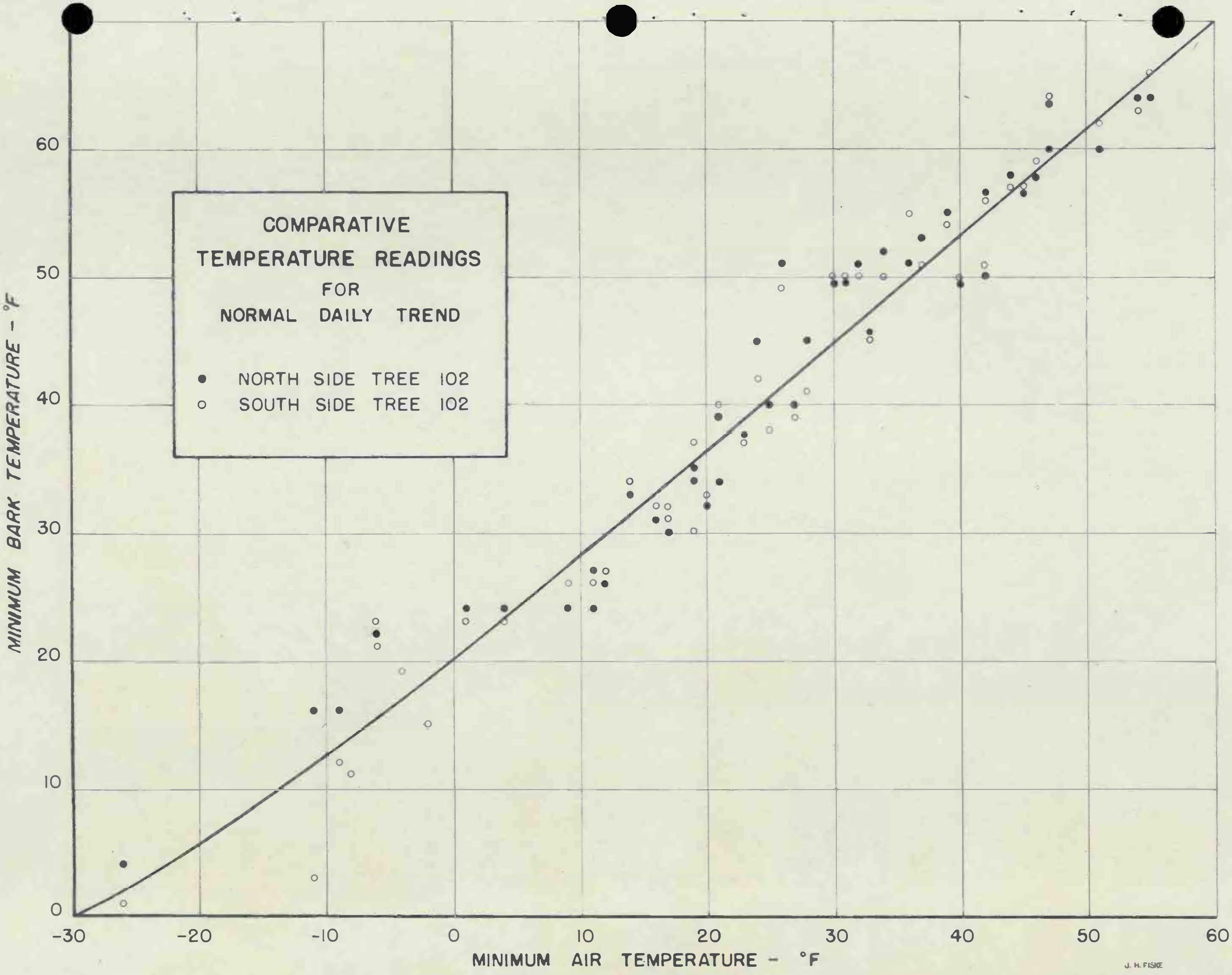

COMPARATIVE
TEMPERATURE READINGS
FOR
NORMAL DAILY TREND
NORTH SIDE TREE 102
SOUTH SIDE TREE 102
MINIMUM BARK TEMPERATURE - °F
MINIMUM AIR TEMPERATURE - °F
0
10
20
30
40
50
60
-30
-20
-10
0
10
20
30
40
50
60
J. H. FISKE

FIGURE 3

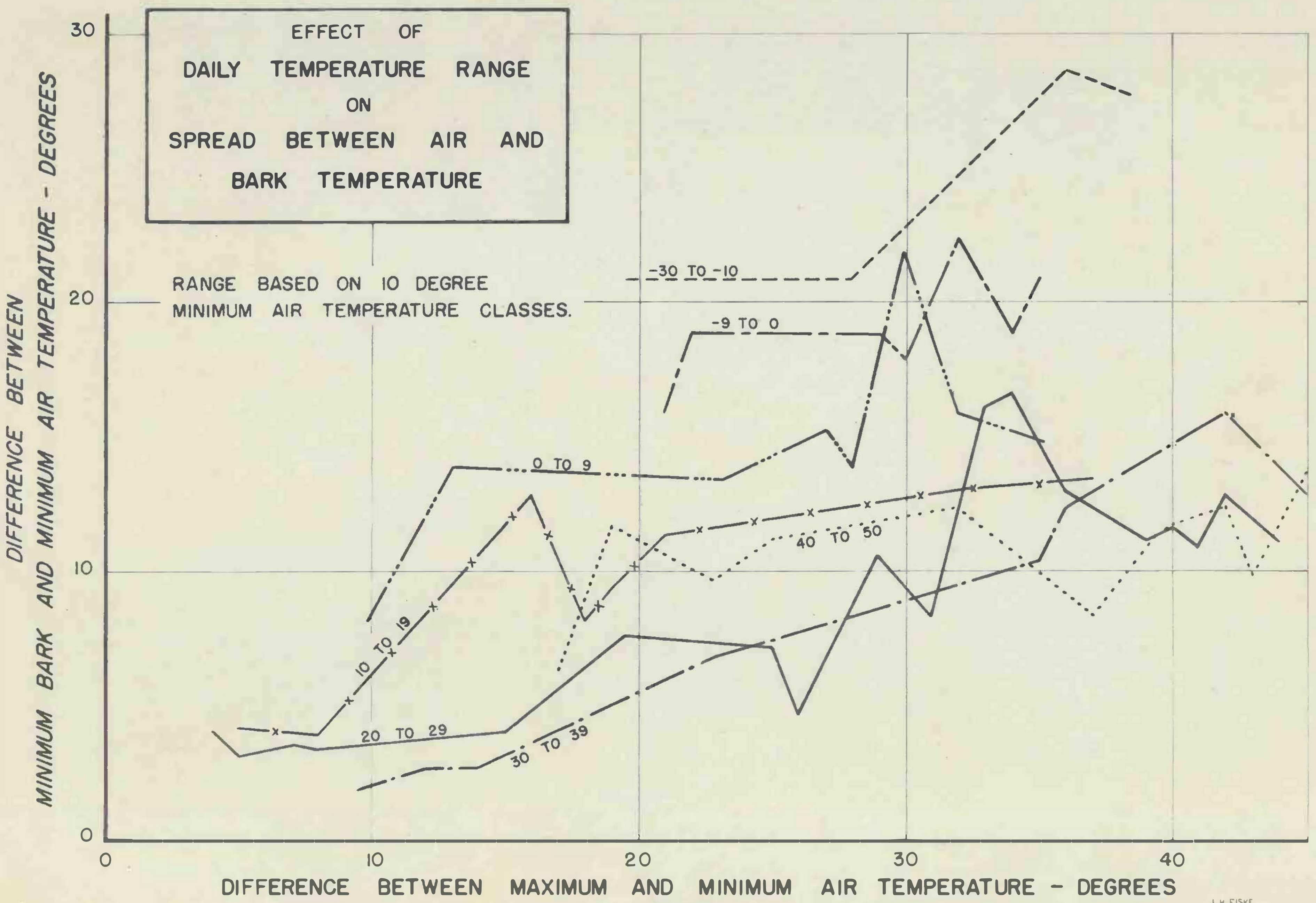

EFFECT OF
DAILY TEMPERATURE RANGE
ON
SPREAD BETWEEN AIR AND
BARK TEMPERATURE
RANGE BASED ON 10 DEGREE
MINIMUM AIR TEMPERATURE CLASSES.
-30 TO -10
-9 TO 0
0 TO 9
10 TO 19
20 TO 29
30 TO 39
40 TO 50
DIFFERENCE BETWEEN
MINIMUM BARK AND MINIMUM AIR TEMPERATURE - DEGREES
30
20
10
0
0
10
20
30
40
DIFFERENCE BETWEEN MAXIMUM AND MINIMUM AIR TEMPERATURE - DEGREES
J. H. FISKE

FIGURE 4

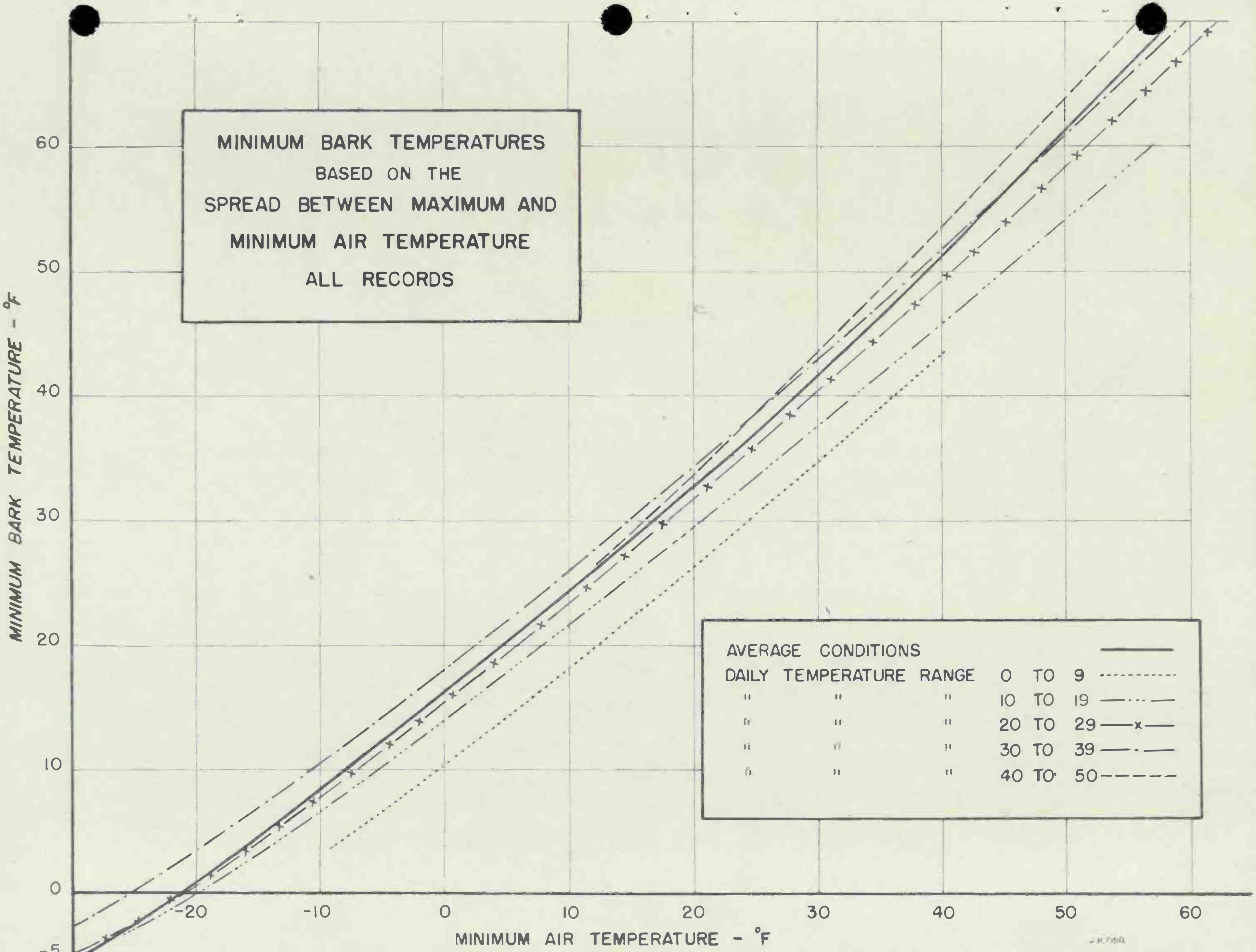
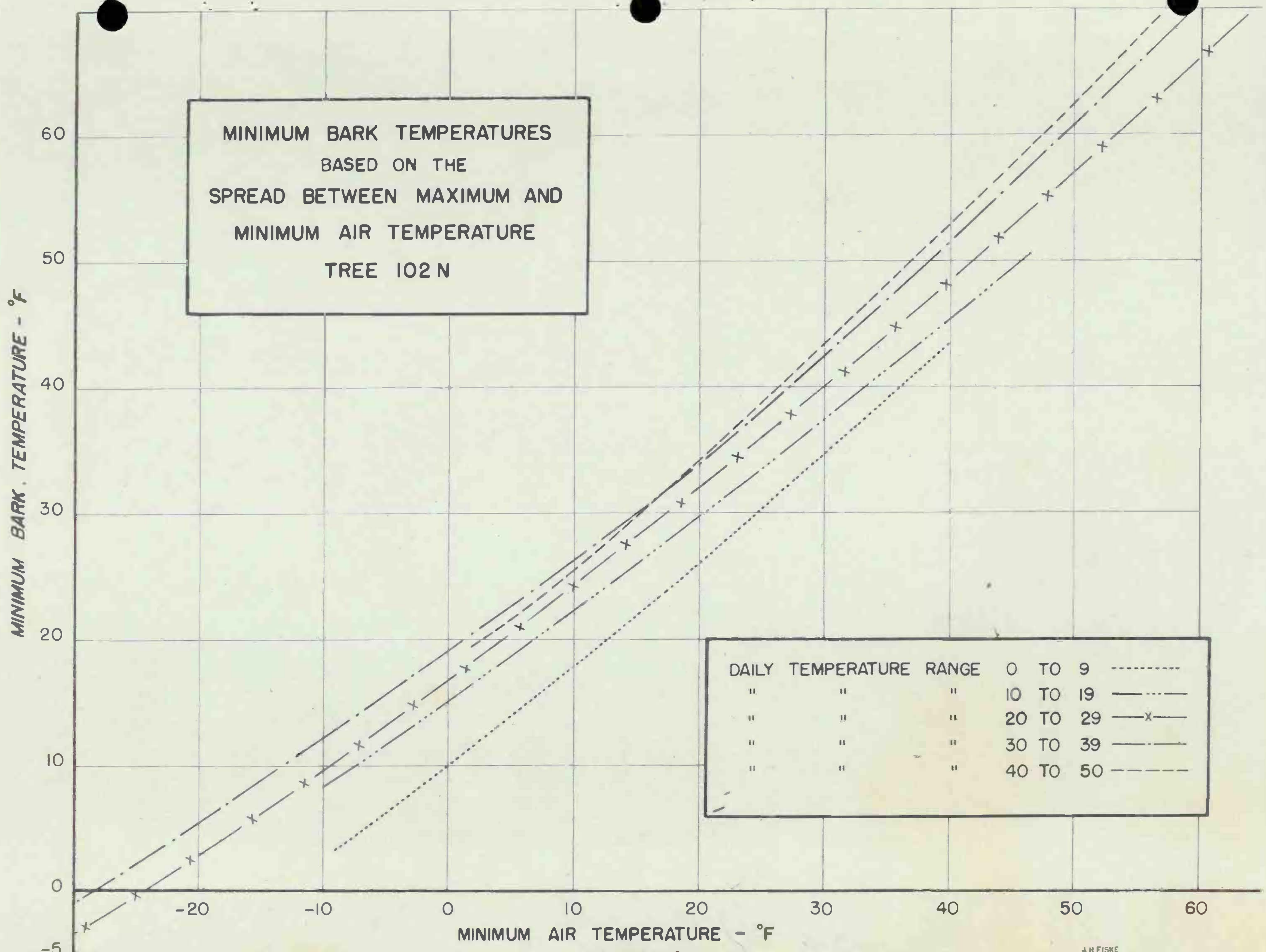

MINIMUM BARK TEMPERATURES
BASED ON THE
SPREAD BETWEEN MAXIMUM AND
MINIMUM AIR TEMPERATURE
ALL RECORDS
AVERAGE CONDITIONS
DAILY TEMPERATURE RANGE 0 TO 9
" " " 10 TO 19
" " " 20 TO 29
" " " 30 TO 39
" " " 40 TO 50
MINIMUM BARK TEMPERATURE - °F
MINIMUM AIR TEMPERATURE - °F
60
50
40
30
20
10
0
-5
-20
-10
0
10
20
30
40
50
60

FIGURE 5



MINIMUM BARK TEMPERATURES
BASED ON THE
SPREAD BETWEEN MAXIMUM AND
MINIMUM AIR TEMPERATURE
TREE 102 N
DAILY TEMPERATURE RANGE 0 TO 9
" " " 10 TO 19
" " " 20 TO 29
" " " 30 TO 39
" " " 40 TO 50
MINIMUM BARK TEMPERATURE - °F
MINIMUM AIR TEMPERATURE - °F
60
50
40
30
20
10
0
-5
-20
-10
0
10
20
30
40
50
60
J.H FISKE

FIGURE 6

Table II

MINIMUM AIR AND BARK TEMPERATURES USED IN DETERMINING RELATIONSHIP OF MINIMUM AIR AND BARK TEMPERATURES

Date	Min. air temp.	Minimum Bark Temperatures			
		BE49	BE54	BE72	BE75
1934					
5/8	40	48			
5/13	35	53			
5/18	30	45			
5/23	42	58			
5/28	47	55			
6/2	33	40			
6/7	43	46			
6/12	45	59			
6/17	43	60			
6/22	40	56	53		
6/27	34	48	44		
7/2	61	72	69		
7/7	42	67	53		
7/17	47	63	58		
7/22	37	54			
7/27	43	64			
8/1	41	62			
8/6	39	58			
8/11	43	65			
8/16	42	64			
8/21	46	67			
10/20	37			46	
10/25	30			40	
10/30	42			50	
11/4	36			40	
11/9	24			30	
11/14	36			44	
11/19	31			36	
11/24	20			29	
11/29	25			32	
12/4	17			29	
12/9	19			30	
12/14	33			36	
12/19	34			36	
12/24	34			38	
12/29	24			31	
1935					
1/3	9			27	
1/8	18			32	
1/13	25			31	
1/18	26			30	

Table II (Cont.)

Date	Min. air Temp.	Minimum Bark Temperatures BE49	BE54	BE72	BE75	BE87	BE88
1935							
1/23	23			35			
1/28	19			32			
2/2	21			38			
2/7	22			37			
2/12	14			29			
2/17	28			35			
2/22	35			40			
2/27	26			35			
3/4	21			33			
3/9	12			29			
3/14	30			38	37		
3/19	13			27	28		
3/24	14			27	28		
3/29	28			36	36		
4/3	33			40	40		
4/8	27			35	35		
4/13	36			43	43		
4/18	28			38	39		
4/23	30			38	39		
4/28	27			42	45		
5/3	29			37	40		
5/8	31			44	47		
5/13	29			42	44		
5/18	27			39	44		
5/23	41			51	53		
5/28	38			49	52		
6/2	37			46	50		
6/7	51			60	63		
6/12	50			57	60		
6/17	36			47	52		
6/22	44			55	60		
6/27	50		BE91	55	60	60	
7/2	38		52		52	52	
7/7	40		55		53	52	
7/12	35		64			59	56
7/17	47		69			63	62
7/22	53		65			60	60
7/27	38		62			53	53
8/1	36		57			52	50
8/6	44		62			60	54
8/11	46		68			60	60
8/16	36		57			51	53
8/21	46		66			55	58
8/26	52		69			62	64
8/31	48						59

Table II (Cont.)

Date	Min air temp.	Minimum Bark Temperature BE49	BE91	BE72	BE75	BE87	BE88
1935							
9/5	45						58
9/10	44						57
9/15	47						53
9/20	40						54
9/25	34						50
9/30	37						51
10/5	30						44
Additional Cold Temperatures for these Trees							
1934							
12/1	19			29			
12/2	10			25			
12/3	12			25			
1935							
1/1	4			25			
1/2	7			25			
1/9	15			30			
1/10	8			27			
1/11	4			24			
1/12	1			24			
1/15	- 3			22			
1/21	15			25			
2/10	9			26			
2/14	2			25			
2/15	4			24			
3/5	13			26			
3/6	11			32			
3/7	18			32			
3/8	13			30			
3/10	1			25			
3/11	14			30			
3/18	9			27	28		
3/22	10			27	26		
3/24	12			26	27		
3/27	12			28	28		

Table II (Cont.)
Original Data

Date	Min Air Temp.	Min. Bark Temp 102N	102S	103N	103S
1936					
7/27	49	68	60	63	60
8/1	55	64	64	65	64
8/6	51	62	60	62	60
8/11	57	64	62	62	61
8/16	44	57	58	58	57
8/21	42	55	56	55	54
8/26	37	52	53	50	50
8/31	44	57	58	55	55
9/5	45	52	52	51	50
9/10	38	53	55	52	52
9/15	21	37	40	34	
9/20	40	51	56	50	50
9/25	45	55	58	54	54
9/30	37	49	49	47	46
10/5	34	46	45	43	42
10/10	42	53	54	51	51
10/15	28	42	45	39	37
10/20	28	42	43	39	36
10/25	27	40	42	39	37
10/30	28	40	43	38	37
11/4	21	32	33	30	27
11/9	19	30	33	29	
11/14	26	38	40		36
11/19	26	42	42	40	38
11/24	16	32	33	29	26
11/29	12	26	28	25	
12/4	8	30	26	21	18
12/9	26	29	33	33	30
12/14	27	35	33	33	30
12/19	26	29	27	32	28
12/24	30	36	34	33	30
12/29	13	27	27	17	22
1937					
1/3	- 2	18			14
1/8	-24	- 3	- 9	- 4	- 4
1/13	- 1	15	15	13	10
1/18	20	29	26	25	22
1/23	- 7	11		10	
1/28	11	25	23	22	17

Date	Min Air Temp.	Min. Bark Temp. 102N	102S	103N	103S
2/12	28	35		33	29
2/22	19	33	35	30	23
2/27	21	33	30		
3/4	28	35	33		
3/9	32	39	41		
3/14	29	36	37		
3/19	17	35	36		
3/24	21	37	35		
3/29	12	33	31		
4/3	42	49	37		

Additional Cold Weather Temperatures

Date	Min Air Temp.	102N	102S	103N	103S
1936					
12/1	9	25	25	22	17
12/3	9	27	25	21	18
12/10	9	27	25	24	17
12/11	9	26	25	23	17
12/31	- 5	22	20	7	13
1937					
1/3	- 2	17	8	3	
1/4	2	18			
1/5	4	23	24	19	16
1/6	- 9	12		5	
1/7	-12	3			
1/11	8	25	22	20	23
1/12	- 1	12	10	8	3
1/17	8	23	22	20	17
1/19	6	20		16	13
1/20	-22	4	3	- 2	- 3
1/22	4	23		12	
1/24	8	23		21	
1/29	11	25	23	21	22
1/30	1	19	17	15	11
2/14	8	27		25	20
2/20	1	23	24	19	15

Table III

MINIMUM TEMPERATURES USED TO DETERMINE EFFECT OF DAILY TEMPERATURE TREND: INDIVIDUAL TREE AND CHECK ORIGINAL DATA.

Date	Min. Air Temp.	Daily temp. trend					Min. Bark Temperatures			
		N	S.M.	L.M.	E.M.		BE49	BE54	BE72	BE75
1934										
5/15	36	x					56			
5/17	41		x				52			
5/27	38	x					49			
5/29	43				x		51			
6/1	29				x		37			
6/6	43	x					48			
6/8	38	x					46			
6/15	44	x					58			
6/25	38	x						47		
6/26	40		x				48	47		
7/1	50	x					66	62		
7/2	61	x					72	68		
7/6	44	x					60	55		
7/14	44	x					65	58		
7/21	36	x					60			
7/27	42	x					64			
8/3	47	x					62			
8/10	43	x					64			
8/17	45	x					64			
10/20	36				x				46	
10/21	38		x						45	
10/23	28				x				37	
10/24	42		x						45	
10/26	28	x							42	
10/29	39		x						50	
10/30	42		x						50	
11/3	32			x					39	
11/4	36		x						40	
11/9	24	x							36	
11/12	29		x						43	
11/14	34				x				44	
11/18	32		x						37	
11/19	31		x						35	
11/22	33		x						35	
11/24	20			x					29	
12/2	10	x							25	
12/3	12				x				25	
12/5	17			x					28	
12/7	18			x					29	
12/9	19			x					30	
12/11	24		x						34	
12/14	33		x						37	
12/20	38		x						40	

Table III (Cont.)

Date	Min Air Temp	Daily temp. Trend					Minimum Bark Temperature				
		N	S.M.	L.M.	E.M.		BE49	BE54	BE72	BE75	
12/31	8			x					25		
1935											
1/1	4	x							25		
1/2	6	x							25		
1/3	9	x							27		
1/6	24			x					33		
1/9	15				x				30		
1/12	1	x							24		
1/13	25				x				33		
1/17	25		x						30		
1/19	- 5	x							18		
1/21	16				x				25		
1/26	23		x						34		
2/4	33		x						39		
2/8	31		x						36		
2/10	9			x					26		
2/14	2	x							25		
2/17	28		x						35		
2/21	30				x				40		
2/26	21				x				33		
2/27	26				x				35		
2/28	30				x				35		
3/10	2	x							25		
3/15	20				x				30	29	
3/17	24		x						33	33	
3/24	12				x				26	27	
3/25	31		x						35	34	
4/1	32				x				42	40	
4/7	32		x						35	38	
4/21	26				x				44	44	
5/12	23	x							38	40	
6/7	51	x							60	63	
6/11	50				x				58	60	
6/16	49	x					BE87		54	55	
7/14	53	x					65		72	64	
7/15	55	x					65		70	63	
7/22	53		x				65		65	60	
8/13	55	x					66		74	68	
8/27	61	x					65		70	65	
9/14	47				x					54	

Table III (Cont.)

Date	Min. Air Temp.	Daily Temp. Trend N.	S.M.	L.M.	E.M.		Minimum Bark Temperatures 102S	102N	103S	102N
1936										
7/23	54	x					64	66	65	67
7/25	44	x					58	57	57	59
7/28	45	x					57	57	58	60
8/1	56				x		64	64	64	65
8/2	51	x					60	62	62	62
8/4	53	x					64	63	64	65
8/7	46	x					58	59	58	59
8/8	42	x					56	56	55	57
8/13	47	x					60	64	61	63
8/17	44	x					58	57	57	59
8/20	39	x					55	54	52	50
8/23	36	x					51	55	49	50
8/26	37	x					53	51	50	50
9/3	40		x				51	51	47	48
9/4	41				x		52	52	49	50
9/5	45				x		52	53	50	51
9/11	31	x					50	50	46	47
9/12	34	x					52	50	47	49
9/13	24	x					45	42	37	39
9/14	21	x					40	39	33	35
9/16	28	x					45	41	39	40
9/19	36	x					51	49	46	46
9/26	37				x		49	50	48	49
10/3	42	x					51	50	48	49
10/4	40	x					50	50	46	49
10/10	42		x				54	50	51	52
10/17	33	x					45	45	40	43
10/23	27	x					40	39	35	41
10/31	23	x					37	37	30	33
11/1	25		x				35	35	28	31
11/4	21		x				34	33	27	30
11/7	11	x					24	26	21	25
11/8	19		x				33	30		29
11/12	21		x				35	35	26	33
11/13	26		x				39	37	35	
11/14	26	x					40	38	44	
11/15	44		x				46	47	44	
11/19	29				x		43	42	37	40
11/20	27		x				41	40	35	37
11/27	18		x				34	33	27	29
11/30	12	x					30	27		
12/1	9			x			25	24	17	22
12/2	15			x			29	30	23	25
12/3	9			x			25	27	18	21
12/4	8			x			26	27	17	20
12/5	28		x				33	35	28	30

Table III (Cont.)

Date	Min. Air Temp.	Daily Temp. Trend N.	S.M.	L.M.	E.M.		Minimum Bark Temperatures 102S	102N	103S	103N
1936										
12/6	22			x			30	33	26	30
12/7	32		x				35	36	31	34
12/8	32		x				35	36	31	35
12/10	9	x					24	26	17	24
12/11	9		x				25	26	17	22
12/14	28		x				33	35	30	34
12/15	33				x		37	37	34	37
12/16	24				x		32	34	27	31
12/17	15		x				27	30	21	26
12/19	25				x		33	35	28	32
12/21	34		x				38	40	35	39
12/26	20				x		25	34	24	24
12/28	19		x				24	30	21	25
1937										
1/2	- 9	x						15	12	4
1/6	- 9	x					26	12		
1/8	-24			x			6	- 3	- 9	- 4
1/9	-11	x					16	3	7	10
1/11	19		x				24	25	17	20
1/12	- 8			x			10	12	3	8
1/13	- 1				x		15	20	10	18
1/15	21		x				26	23	24	26
1/16	9				x		22	24	21	20
1/17	8				x		23	23	18	20
1/18	20		x				26	24	22	25
1/20	-26	x					4	1	- 2	- 2
1/21	-22				x			1		- 3
1/22	4		x					13		12
1/23	- 8	x						11		10
1/24	12		x					23		21
1/25	- 5	x						15		13
1/26	21		x				25	26	23	25
1/27	18		x				25	27	21	25
1/28	11				x		23	25	17	22
1/31	- 4				x		15	16	9	14
2/1	21		x				25	27	21	24
2/9	- 4	x						19	11	17
2/10	8		x					23	17	20
2/11	23		x					27	25	30
2/12	28		x					35	29	33
2/13	19		x					27	25	30
2/14	8			x				27	20	25
2/19	13		x				26	24	22	25
2/20	1	x					24	23	15	19
2/21	9				x		26	23	22	24
2/22	20		x				30	27	29	25

Table IV

MINIMUM AND MAXIMUM AIR TEMPERATURES AND MINIMUM BARK TEMPERATURES USED TO DETERMINE THE EFFECT OF DIFFERENCES OF MINIMUM AND MAXIMUM AIR TEMPERATURES ON MINIMUM BARK TEMPERATURES.

Maximum Air Temperatures for Day Preceding Minimum.

	Air Temp		Min. Bark Temp.					Air Temp.		Min. Bark Temp.			
Date	Max.	Min.	102S	102N	103S	103N	Date	Max.	Min.	102S	102N	103S	103N
1936													
							12/4	37	8	26	27	17	20
7/23	94	54	64	66	65	67	12/5	35	28	33	35	28	30
7/25	89	44	58	57	57	59	12/6	41	22	30	33	26	30
7/28	87	45	57	57	58	60	12/7	44	32	35	36	31	34
8/1	93	56	64	64	64	65	12/8	46	32	35	36	31	35
8/2	91	51	60	62	62	62	12/10	41	9	24	26	17	24
8/4	92	53	64	63	64	65	12/11	44	9	25	26	18	22
8/7	78	46	58	59	58	59	12/14	53	27	32	34	29	33
8/8	89	42	56	56	55	57	12/15	55	33	37	37	33	37
8/12	72	47	60	64	61	63	12/16	55	24	32	34	27	31
8/17	84	44	58	57	57	59	12/17	36	15	27	30	21	26
8/20	74	39	55	54	52	56	12/19	58	35	43	45	38	42
8/23	86	36	51	55	49	50	12/21	46	34	36	38	34	37
8/26	79	37	53	51	52	52	12/23	46	37	38	40	35	39
9/3	63	40	51	51	47	48	12/26	26	20	25	34	24	24
9/4	64	41	52	52	49	50	12/28	37	19	24	30	21	25
9/5	62	45	52	53	50	51	1937						
9/11	81	31	50	50	46	48	1/2	25	- 9		17	12	4
9/12	78	34	52	48	47	49	1/6	26	- 9	8	12		
9/13	58	24	45	42	37	39	1/8	12	-24	6	1	- 2	- 2
9/14	54	21	40	39	35	33	1/9	8	-11	16	5	7	10
9/16	70	28	45	41	39	40	1/11	25	19	24	26	17	20
9/19	81	36	51	49	46	46	1/12	26	- 8	10	12	3	8
9/26	73	37	49	50	48	50	1/15	29	21	26	23	24	26
10/3	77	42	51	50	48	49	1/13	20	- 1	15	20	10	18
10/4	76	40	50	50	46	49	1/16	37	9	22	24	21	20
10/10	85	42	54	50	51	52	1/17	21	8	23	23	18	20
10/17	68	33	45	45	40	43	1/18	34	20	26	24	22	27
10/23	67	27	40	39	35	41	1/20	12	-26	4	4	- 2	- 2
10/31	52	23	37	37	30	33	1/21	5	-22		1		- 3
11/1	48	25	35	35	28	31	1/22	14	4		13		12
11/4	54	21	34	33	27	30	1/23	22	- 8		11	10	10
11/7	48	11	24	26	21	25	1/24	25	12		23		21
11/8	56	19	33	30		29	1/25	24	- 5		15		13
11/12	60	21	35	35	26	33	1/26	29	21	25	26	23	25
11/13	67	26	39	37	35		1/27	27	18	25	27	21	25
11/14	68	26	40	38	36		1/28	27	11	23	25	17	22
11/15	63	44	56	57	54		1/31	18	- 4	15	16	9	14
11/19	66	29	43	42	39	40	2/1	26	21	25	27	21	24
11/20	71	27	41	40	35	37	2/9	28	- 4		19	11	17
11/27	57	18	34	33	27	29	2/10	31	8		23	17	20
11/30	50	12	30	27			2/11	38	23		27	25	30
12/1	43	9	25	24	17	22	2/12	32	28		35	29	33
12/2	46	15	29	30	23	25	2/13	37	19		27	25	30
12/3	40	9	25	27	18	21	2/14	32	8		27	20	25
							2/20	31	1	24	23	17	19
							2/21	36	9	26	23	22	24
							2/22	44	20	30	27	29	25

Table IV (Cont.)

Additional data for tree 102N.

Date	Air temp. Max.	Air temp. Min.	Min. Bark Temp. 102N	Date	Air temp. Max.	Air temp. Min.	Min. Bark Temp. 102N	Date	Air temp. Max.	Air temp. Min.	Min. Bark Temp. 102N
1936				10/1	79	37	49	12/9	43	26	34
				10/2	81	38	50	12/12	45	9	26
8/3	91	52	62	10/5	71	34	46	12/13	47	16	30
8/5	95	50	61	10/6	74	32	42	12/18	42	21	32
8/6	95	51	62	10/7	79	37	49	12/20	45	27	35
8/9	92	52	63	10/8	81	33	47	12/22	43	31	35
8/10	88	61	72	10/9	83	38	50	12/24	41	20	36
8/11	81	56	64	10/11	84	37	50	12/25	42	11	27
8/13	85	51	60	10/12	77	34	47	12/27	29	23	32
8/14	89	47	67	10/13	73	34	47	12/29	31	18	27
8/15	89	49	60	10/14	79	37	49	12/30	27	22	27
8/16	88	44	57	10/15	68	28	42	12/31	25	- 5	21
8/18	82	41	55	10/16	61	27	41				
8/19	86	40	54	10/18	75	38	48	1937			
8/21	86	42	55	10/19	67	42	50				
8/22	82	42	55	10/20	68	28	42	1/1	21	7	25
8/24	78	40	53	10/21	63	25	39	1/3	23	- 2	18
8/25	80	36	50	10/22	63	26	38	1/4	30	2	18
8/27	77	41	54	10/24	38	28	39	1/5	32	5	23
8/28	90	42	55	10/25	73	27	40	1/10	18	4	13
8/29	93	45	57	10/26	60	25	38	1/13	20	- 1	15
8/30	90	44	56	10/27	63	22	37	1/14	22	14	24
8/31	87	44	57	10/28	64	19	35	1/19	23	6	20
9/1	87	41	55	10/29	63	25	38	1/29	24	11	24
9/2	83	39	53	10/30	62	28	40	1/30	26	1	18
9/6	69	40	51	11/2	40	8	25	2/15	26	- 5	21
9/7	81	42	53	11/3	39	15	23				
9/8	85	41	54	11/5	53	20	32				
9/9	85	41	55	11/6	52	17	31				
9/10	84	38	53	11/9	61	19	30				
9/15	59	21	37	11/10	56	17	26				
9/17	80	31	44	11/11	57	21	34				
9/18	84	34	46	11/16	63	31	42				
9/20	91	41	51	11/17	59	27	40				
9/21	92	44	54	11/18	62	28	41				
9/22	87	40	53	11/21	68	22	37				
9/23	85	40	53	11/22	65	21	36				
9/24	90	40	54	11/23	59	18	33				
9/25	89	45	55	11/24	60	16	32				
9/27	70	31	47	11/25	58	19	34				
9/28	77	44	48	11/26	60	18	31				
9/29	82	34	48	11/28	58	14	29				
9/30	79	37	49	11/29	54	12	26				

Table V

Differences in Minimum and Maximum Air Temperatures for 1934 and 1935. Based on Differences Between Min. Night Readings and the Max. of the Preceding Day.

Date	Daily temp. Range	Date	Daily Temp. Range.	Date	Daily Temp. Range	Date	D.T.R.
1934		11/9	33	2/22	18	8/16	41
		11/12	37	2/26	12	8/21	43
5/8	54	11/14	26	2/27	17	8/26	46
5/13	36	11/18	4	2/28	8	8/21	38
5/15	45	11/19	2	3/4	16	9/5	48
5/17	32	11/22	10	3/9	21	9/10	45
5/18	34	11/24	15	3/10	30	9/15	15
5/27	31	11/29	9	3/14	33		
5/28	33	12/2	21	3/15	14		
5/29	30	12/3	12	3/17	24		
6/1	19	12/4	21	3/19	27		
6/2	25	12/5	16	3/24	28		
6/6	15	12/7	29	3/25	7		
6/7	13	12/9	31	3/29	32		
6/8	23	12/11	25	4/1	22		
6/12	38	12/14	27	4/3	13		
6/15	36	12/19	8	4/7	11		
6/17	40	12/20	3	4/8	15		
6/22	42	12/24	14	4/13	20		
6/25	36	12/29	5	4/18	18		
6/26	27	12/31	27	4/21	20		
6/27	28			4/23	11		
7/1	45	1935		4/28	40		
7/2	29			5/3	29		
7/6	40	1/1	33	5/8	37		
7/7	37	1/2	36	5/12	40		
7/14	43	1/3	9	5/15	34		
7/17	37	1/6	24	5/18	30		
7/21	43	1/8	15	5/23	37		
7/22	35	1/9	16	5/28	33		
7/27	50	1/12	30	6/2	35		
8/1	35	1/13	3	6/7	38		
8/6	40	1/17	2	6/11	28		
8/10	45	1/18	6	6/12	32		
8/11	45	1/19	34	6/16	34		
8/16	44	1/21	10	6/17	40		
8/21	47	1/23	18	6/22	44		
10/20	20	1/26	28	6/27	34		
10/21	12	1/28	32	7/2	33		
10/23	17	2/2	28	7/7	28		
10/24	14	2/4	15	7/12	48		
10/25	29	2/7	9	7/17	45		
10/26	41	2/8	5	7/22	29		
10/29	26	2/10	25	7/27	43		
10/30	22	2/12	22	8/1	49		
11/3	10	2/14	31	8/6	38		
11/4	2	2/17	22	8/11	50		
		2/21	12				